



IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

IN RE APPLICATION OF:)
)
WILLIAM BRANDT GOLDSWORTHY, et al.)
)
SERIAL NO.:)
)
FILED: CONTEMPORANEOUSLY HEREWITH) GROUP ART UNIT NO.
)
TITLE: COMPOSITE REINFORCED)
ELECTRICAL TRANSMISSION)
CONDUCTOR)
)
)
EXAMINER:)

AMENDMENT A (PRELIMINARY)

Commissioner of Patents
and Trademarks
Washington, D.C. 20231

Sir:

IN THE SPECIFICATION

Amend pages 15, 16, 17, 18 and 19 as indicated on the pages
having marking showing changes therein.

IN THE CLAIMS

Please amend Claims 1, 5, 6, 7-12, as shown on the pages
having markings therein showing changes.

Claims, 2, 3, and 4 are being resubmitted and/or re-presented
herein for the convenience of the U.S. Patent and Trademark Office.

Please cancel Claims 13-18 without prejudice.

Please add the following new Claims 19-29.

REMARKS

The present Amendment is being submitted contemporaneously with the filing of this continuation application and also in response to an Office Action dated August 22, 2001, in the parent patent application Serial No. 09/500,285.

It is noted that in the Office Action dated August 22, 2001, of the parent patent application, a final rejection was made even though the U.S. Patent and Trademark Office cited two new prior art references, which were the main references cited in this last Office Action. Indeed, it is believed that the making of that rejection, a final rejection, is not only unfair, but quite inequitable inasmuch as the prior art cited by the Examiner in the second Office Action could have been cited in the first Office Action. Any failure to cite that prior art was not a result of any action or inaction on the part of the applicant.

Notwithstanding the foregoing, in that Office Action, the Examiner did raise several objections with regard to terminology in the specification and presumably in the claims, inasmuch as the specification identified both strands of wire and strands of fiber reinforcing material. In order to obviate any objection, the applicant has proposed amendments to the specification. These amendments merely attempt to eliminate any ambiguity with respect to strands of fiber and strands of wire, although each are commonly referred to as strands. These changes in the specification do not add any new matter.

The claims in the application were rejected on the basis of the Bryant Patent No. 3,324,233 taken in combination with the Olson Patent No. 5,808,239. Other than a secondary reference to Lichtenberger, the entire rejection was based on the combination of these two references. However, reconsideration of the rejection is respectfully urged.

First of all, turning again to the Lichtenberger patent, this reference was cited only to show use of a fiber optic cable in some type of bundle. However, contrary to any allegation that Lichtenberger may disclose a current carrying conductor along with that fiber optic cable, it is noted that the Lichtenberger bundle literally calls only for a cable jacket such as that jacket 18, a textile serve such as that element 16, a viscous coating 14, and a fiber optic cable. Considering the components of which the bundle in Lichtenberger is formed, the serve 16 is a textile material and non-conductive, the viscous coating is obviously non-conductive, and the cable jacket only serves as a protective outer layer. It is apparent that the Lichtenberger patent is only providing an outer coating combination to protect the fiber optic cable, and there is no suggestion within the four corners of this reference that the cable is capable of conducting any type of electrical signal, other than that perhaps carried by the fiber optic cable.

Turning now to the primary references employed in the rejection of this application, the Bryant patent discloses a cable complex having an electrically insulative core 16. However, Bryant describes the core 16 as being formed of a silicon material, hardly

an electrical conductor. There are electrical conductors 20. The only non-electrical components in Bryant are basically insulator materials and carry no load whatsoever. Indeed, and contrary to the allegation in paragraph 6 of the Office Action of this parent application that the "central load carrying core (16) which is of sufficient cross-sectional size to support the load of the conductor" is completely erroneous. A central core formed of a silicon material would carry hardly anything but a minuscule amount of any load, if at all. Indeed, and notwithstanding the lack of tensile strength loading of silicon, it obviously is not going to carry any significant load whatsoever, and certainly not even a load equivalent to a load of a conventional steel core electrical conductor.

The Examiner basically takes the position that the use of a composite material is taught by Olsson. Specifically, and at the outset, Olsson relates to a video push-cable. Again, there is nothing within the four corners of Olsson which suggests the use of this push-cable complex to carry electrical signals or electrical current for any appreciable distance. Indeed, inasmuch as Olsson is only concerned with carrying a miniature television type projector, or camera, it is obviously unrelated prior art. In fact, the Olsson patent represents prior art so completely non-analogous that it is not a proper reference to cite against any of the claims in the instant application. Therefore, it is believed that the Olsson patent should be withdrawn.

Notwithstanding the foregoing, it is also to be noted that Olsson only discloses a push rod 28 which is formed of a composite material and in addition, the core 54 in Olsson is the actual push rod itself. In fact, from a simple reading of the Olsson patent, the composite sleeve 28 merely surrounds and protects the push rod 54.

The only conductor in the entire bundle of Olsson is that conductor 32 which is an insulated conductor. It is only carrying a very small current, and is certainly not of sufficient magnitude to carry any significant amount of current.

In addition to the foregoing, it is also to be noted that the composite push rod 28 is not of a rigid type construction which would allow for carrying any significant amount of load. By definition, the composite forms part of the cable bundle in Olsson. The cable in Olsson must, by its very nature, be flexible and bendable so as to be pushed through a pipe. Indeed, it must be capable of even bending at 90° angles of the pipe. Otherwise, it would not function as a push cable for a video device.

In contrast to the Olsson patent, William Brandt Goldsworthy, one of the applicants herein, is an inventor of numerous reinforced plastic composite devices, including machinery for making these composite devices. Mr. Goldsworthy must have over some 30 patents in his name on various composite materials and apparatus for making composite materials and products. The inventors including Mr. William Brandt Goldsworthy, examined these prior art references and

believe that they are so remote so as not to be realistically citable in the instant application.

Considering the combination of Olsson and Bryant, it is to be noted that there is no suggestion that the push rod cable of Olsson could be combined in any way with the teachings of Bryant. To merely suggest that Olsson has a composite cable and therefore suggest that it is combinable with Bryant is completely without justification. Indeed, Mr. Goldsworthy has already developed conduit of reinforced plastic composite materials long prior to this present application. Even if the cable taught by Olsson were combinable with Bryant, it would only be a non-rigid cable and therefore, one incapable of carrying any substantial loading as such. Consequently, it is believed that the combination of references relied upon by the Examiner is not sufficient to reject the claims of this application.

Each of the claims in this application have been amended compared to the claims in the original patent application, to recite that the load carrying core carries the primary tensile loading of the conductor. It is apparent that this is not true in each of Bryant and in Olsson. Secondly, the claims now recite that the load carrying core has a sufficiently high tensile strength to carry the entire loading which was carried by a steel core in a conventional cable. Indeed, the load carrying core can actually carry the entire load of the cable with essentially none of that load being carried by the electrical conductors.

In this application as well as in many applications, both the Examiners and the applicants, as well as their attorneys, become enmeshed in the prosecution of the application and the details of teachings of the prior art, and tend to overlook the actual essence of the invention and the contributions made by that invention. Heretofore, there has not been any electrical conductive cable for long distance carrying of electrical current and signals in which a central core is capable of carrying the entire load of the conductor. As a result, the electrical conductors themselves had to carry some of the load. Consequently, these electrical conductors were made of a material which compromised the current carrying capabilities in order to provide some load carrying capabilities. Thus, aluminum wires, to carry some of the load, had to be alloyed. In this case, the amount of current carrying capability was consequently reduced. In accordance with the present invention, it is possible to use pure smelted aluminum which has very little load carrying capability whatsoever. However, by the use of this smelted aluminum, a significantly greater amount of electrical current can be carried by this cable.

If it were indeed so obvious as the Examiner seems to suggest, then one must inquire as to why there has not been any current carrying cable of this type. The fact remains that none have been developed.

It is also noteworthy that one of the largest electrical transmission cable companies in this country has already assumed a license under these patent rights. Moreover, a substantial amount

of money has already been generated based on these cables. Again, the applicant must inquire that if it is so obvious, as the Examiner seems to contend, one must again inquire as to why would fairly large companies pay a substantial amount of money to acquire licensing rights when the cable is allegedly so obvious. The fact remains that this cable is not obvious and indeed, it is a significant contribution which has been provided by the applicants herein.

As indicated previously, these claims call for the fact that the core has sufficiently high tensile strength to carry the entire loading previously carried by a steel core in a conventional cable. Moreover, it is capable of carrying the entire load. In addition, the claims call for the fact that the outer sheath carries only a small amount of the tensile loading on the conductor. It is urged that the prior art does not disclose this type of conductor and therefore, favorable reconsideration and allowance is respectfully solicited.

For the same reasons, it is believed that Claims 7-12 are allowable and allowance therefor is respectfully solicited. The applicant has added new claims such as Claims 26 and 27 which call for the fact that the sheath is formed of a non-alloyed aluminum. As indicated previously, this was not possible in the prior art. Consequently, it is believed that claims of this type also contain allowable subject matter.

The applicant has also added new Claims 20-29 which deal with the electrical current carrying cable, as well as the fiber optic

cable. As indicated in the specification, no one has provided an electrical load carrying cable which is also capable of carrying a fiber optic cable therewith. Previously, the fiber optic cable was literally wound about the exterior of the electrical conductor. The environmental erosion problems alone were significant, not to mention the various other problems associated with carrying an exposed fiber optic cable. Consequently, it again remained for the applicant to provide a load carrying cable which is capable of also carrying fiber optic signals.

It is believed that each of the claims in this applicant patentably distinguish over these prior art references and therefore, favorable reconsideration and allowance is respectfully solicited.

Dated: Dec. 24, 2001

Respectfully submitted,



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CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited
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CLEAN VERSION - REPLACEMENT PAGES

1 (Once Amended)

An electrical current carrying conductor for long distance transmission of electrical current, said current carrying conductor comprising:

- a) a relatively solid high tensile strength central load carrying core formed of a fiber containing reinforced composite material and being of sufficient cross-sectional size to support the high tensile loading on the conductor and having a sufficiently high tensile strength to carry the entire loading carried by a steel core in a conventional cable; and
- b) an outer highly conductive electrical current carrying sheath completely surrounding said load carrying core for carrying electrical current over said long distance and where said sheath carries only a small amount of tensile loading on the conductor.

2 (Resubmitted)

The electrical current carrying conductor of Claim 1 further characterized in that said outer sheath is comprised of aluminum.

CLEAN VERSION - REPLACEMENT PAGES

3 (Resubmitted)

The electrical current carrying conductor of Claim 1 further characterized in that said reinforced composite material is comprised of a plurality of aligned reinforcing fibers embedded in a thermoplastic composite matrix.

4 (Resubmitted)

The electrical current carrying conductor of Claim 1 further characterized in that said central load carrying core is comprised of a plurality of individual sections which are capable of being separated from one another for purposes of splicing.

5 (Once Amended)

The electrical current carrying conductor of Claim 4 further characterized in that said individual sections are concentrically arranged to form a cylindrically shaped conductor core.

6 (Once Amended)

The electrical current carrying conductor of Claim 5 further characterized in that said individual sections are somewhat trapezoidal shaped and when abutted against one another form a central bore sized to receive a fiber optic cable.

CLEAN VERSION - REPLACEMENT PAGES

7 (Once Amended)

A method of producing a long distance transmission current carrying conductor, said method comprising:

- a) bringing a plurality of individual reinforced plastic composite sections together to form a generally cylindrically shaped conductor core and being of sufficient cross-sectional size to support the primary tensile loading on the conductor and having a sufficiently high tensile strength to carry the entire loading carried by a steel core in a conventional cable; and
- b) locating on an outer cylindrically shaped surface of said core an outer highly conductive electrical current carrying conductor.

8 (Once Amended)

The method for producing a long distance transmission current carrying conductor of Claim 7 further characterized in that said step of locating the current carrying conductor comprises winding individual wires of a highly conductive current carrying conductor about the central core.

9 (Once Amended)

The method for producing a long distance transmission current carrying cable of Claim 8 further characterized in that said method comprises helically winding said wires about said central core.

CLEAN VERSION - REPLACEMENT PAGES

10 (Once Amended)

The method for producing a long distance transmission current carrying conductor of Claim 7 further characterized in that said outer surface is comprised of aluminum wires.

11 (Once Amended)

The method for producing a long distance transmission current carrying cable of Claim 7 further characterized in that said reinforced plastic composite sections are each comprised of a plurality of aligned reinforcing fibers embedded in a thermoplastic composite matrix.

12 (Once Amended)

The method for producing a long distance transmission current carrying conductor of Claim 7 further characterized in that said method comprises the bringing of the composite sections together about a fiber optic cable so that the current carrying conductor also includes a fiber optic cable extending through said core.

CLEAN VERSION - REPLACEMENT PAGES

20 (New Claim)

An electrical current carrying conductor for long distance transmission of electrical current, said current carrying conductor comprising:

- a) a central load carrying core formed of a fiber containing reinforced composite material and being of sufficient cross-sectional size to support the primary tensile loading on the conductor;
- b) an outer highly conductive electrical current carrying sheath completely surrounding said load carrying core for carrying electrical current over said long distance and where said sheath carries only a small amount of tensile loading on the conductor;
- c) a central bore extending axially through said core; and
- d) a fiber optic cable extending through the central bore allowing the conductor to carry electrical current and fiber optic cable signals with the same conductor.

21 (New Claim)

The electrical current carrying conductor of Claim 20 further characterized in that said outer sheath is comprised of aluminum.

CLEAN VERSION - REPLACEMENT PAGES

22 (New Claim)

The electrical current carrying conductor of Claim 21 further characterized in that said reinforced composite material is comprised of a plurality of aligned reinforcing fibers embedded in a thermoplastic composite matrix.

23 (New claim)

The electrical current carrying conductor of Claim 20 further characterized in that said central load carrying core is comprised of a plurality of individual sections which are capable of being separated from one another for purposes of splicing.

24 (New Claim)

The electrical current carrying conductor of Claim 23 further characterized in that said central load carrying core is cylindrically shaped and said individual sections are concentrically arranged to form a cylindrically shaped conductor.

25 (New Claim)

The electrical current carrying conductor of Claim 24 further characterized in that said individual sections are each somewhat trapezoidal shaped with an arcuate inner edge and where all arcuate inner edges form said central bore sized to receive a fiber optic cable.

CLEAN VERSION - REPLACEMENT PAGES

26 (New Claim)

The electrical current carrying conductor for long distance transmission of electrical current of Claim 1 further characterized in that said electrical current carrying sheath is formed of a non-alloyed aluminum.

27 (New Claim)

The electrical current carrying conductor for long distance transmission of electrical current of Claim 26 further characterized in that said current carrying sheath and said solid load carrying core and a bore to receive a fiber optic cable.

28 (New Claim)

The electrical current carrying conductor for long distance transmission of electrical current of Claim 20 further characterized in that said electrical current carrying sheath is formed of a non-alloyed aluminum.

29 (New Claim)

The electrical current carrying conductor for long distance transmission of electrical current of Claim 28 further characterized in that said current carrying sheath and said solid load carrying core and a bore to receive a fiber optic cable.

VERSION WITH MARKINGS TO SHOW CHANGES

1 (Once Amended)

An electrical current carrying conductor for long distance transmission of electrical current, said current carrying conductor comprising:

- a) a relatively solid high tensile strength central load carrying core formed of a fiber containing reinforced composite material and being of sufficient cross-sectional size to support the high tensile loading on the conductor and having a sufficiently high tensile strength to carry the entire loading carried by a steel core in a conventional cable; and
- b) an outer highly conductive electrical current carrying sheath completely surrounding said load carrying core for carrying electrical current over said long distance and where said sheath carries only a small amount of tensile loading on the conductor.

2 (Resubmitted)

The electrical current carrying conductor of Claim 1 further characterized in that said outer sheath is comprised of aluminum.

VERSION WITH MARKINGS TO SHOW CHANGES

3 (Resubmitted)

The electrical current carrying conductor of Claim 1 further characterized in that said reinforced composite material is comprised of a plurality of aligned reinforcing fibers embedded in a thermoplastic composite matrix.

4 (Resubmitted)

The electrical current carrying conductor of Claim 1 further characterized in that said central load carrying core is comprised of a plurality of individual sections which are capable of being separated from one another for purposes of splicing.

5 (Once Amended)

The electrical current carrying conductor of Claim 4 further characterized in that said individual sections are concentrically arranged to form a cylindrically shaped conductor core.

6 (Once Amended)

The electrical current carrying conductor of Claim 5 further characterized in that said individual sections are somewhat trapezoidal shaped and when abutted against one another form a central bore sized to receive a fiber optic cable.

VERSION WITH MARKINGS TO SHOW CHANGES

7 (Once Amended)

A method of producing a long distance transmission current carrying conductor, said method comprising:

- a) bringing a plurality of individual reinforced plastic composite sections together to form a generally cylindrically shaped conductor core and being of sufficient cross-sectional size to support the primary tensile loading on the conductor and having a sufficiently high tensile strength to carry the entire loading carried by a steel core in a conventional cable; and
- b) locating on an outer cylindrically shaped surface of said core an outer highly conductive electrical current carrying conductor.

8 (Once Amended)

The method for producing a long distance transmission current carrying conductor of Claim 7 further characterized in that said step of locating the current carrying conductor comprises winding [strands] individual wires of a highly conductive current carrying conductor about the central core.

9 (Once Amended)

The method for producing a long distance transmission current carrying cable of Claim 8 further characterized in that said method comprises helically winding said [strands] wires about said central

VERSION WITH MARKINGS TO SHOW CHANGES

core.

10 (Once Amended)

The method for producing a long distance transmission current carrying conductor of Claim 7 further characterized in that said outer [sheath] surface is comprised of aluminum wires.

11 (Once Amended)

The method for producing a long distance transmission current carrying cable of Claim 7 further characterized in that said reinforced plastic composite [material is] sections are each comprised of a plurality of aligned reinforcing fibers embedded in a thermoplastic composite matrix.

12 (Once Amended)

The method for producing a long distance transmission current [carry] carrying conductor of Claim 7 further characterized in that said method comprises the bringing of the composite [section] sections together about a fiber optic cable so that the current carrying conductor also includes a fiber optic cable extending through said core.

VERSION WITH MARKINGS TO SHOW CHANGES

20 (New Claim)

An electrical current carrying conductor for long distance transmission of electrical current, said current carrying conductor comprising:

- a) a central load carrying core formed of a fiber containing reinforced composite material and being of sufficient cross-sectional size to support the primary tensile loading on the conductor;
- b) an outer highly conductive electrical current carrying sheath completely surrounding said load carrying core for carrying electrical current over said long distance and where said sheath carries only a small amount of tensile loading on the conductor;
- c) a central bore extending axially through said core; and
- d) a fiber optic cable extending through the central bore allowing the conductor to carry electrical current and fiber optic cable signals with the same conductor.

21 (New Claim)

The electrical current carrying conductor of Claim 20 further characterized in that said outer sheath is comprised of aluminum.

VERSION WITH MARKINGS TO SHOW CHANGES

22 (New Claim)

The electrical current carrying conductor of Claim 21 further characterized in that said reinforced composite material is comprised of a plurality of aligned reinforcing fibers embedded in a thermoplastic composite matrix.

23 (New claim)

The electrical current carrying conductor of Claim 20 further characterized in that said central load carrying core is comprised of a plurality of individual sections which are capable of being separated from one another for purposes of splicing.

24 (New Claim)

The electrical current carrying conductor of Claim [20] 23 further characterized in that said central load carrying core is cylindrically shaped and said individual sections are concentrically arranged to form a cylindrically shaped conductor.

25 (New Claim)

The electrical current carrying conductor of Claim 24 further characterized in that said individual sections are each somewhat trapezoidal shaped with an arcuate inner edge and where all arcuate inner edges form said central bore sized to receive a fiber optic cable.

VERSION WITH MARKINGS TO SHOW CHANGES

26 (New Claim)

The electrical current carrying conductor for long distance transmission of electrical current of Claim 1 further characterized in that said electrical current carrying sheath is formed of a non-alloyed aluminum.

27 (New Claim)

The electrical current carrying conductor for long distance transmission of electrical current of Claim 26 further characterized in that said current carrying sheath and said solid load carrying core and a bore to receive a fiber optic cable.

28 (New Claim)

The electrical current carrying conductor for long distance transmission of electrical current of Claim 20 further characterized in that said electrical current carrying sheath is formed of a non-alloyed aluminum.

29 (New Claim)

The electrical current carrying conductor for long distance transmission of electrical current of Claim 28 further characterized in that said current carrying sheath and said solid load carrying core and a bore to receive a fiber optic cable.

VERSION WITH MARKINGS TO SHOW CHANGES

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now in more detail and by reference characters to the drawings, which illustrate preferred embodiments of the present invention, C₁ illustrates an electrical transmission cable having a reinforced plastic composite load bearing core 10 and a plurality of outer layers of aluminum wire 12 and 14 extending thereabout.

By further reference to Figure 1, it can be seen that the load bearing core 10 [is] includes a solid reinforced plastic composite member. Also, in the embodiment as illustrated in Figure 1 and the subsequently illustrated and described embodiments, there are three outer aluminum layers 12, 18 and 14 (see Figure 1), although it should be understood that any number of outer layers could be employed depending upon the desired thickness of the outer current conducting sheath to be formed over the core. It can be observed that in this construction, the cable C₁ is similar in appearance to a conventional steel core cable. Consequently, it can be laid in the same fashion or suspended in the same fashion and using the same equipment as that employed for a steel core cable.

Also by further reference to Figure 1, it can be observed that the aluminum layers 12 and 14 are formed of individual [strands] wire bundles 16 and [18] 16¹ which are helically wound about the central core 10. Thus, the [strands] wires can be wound or otherwise applied in any conventional fashion upon the core.

In a preferred embodiment, the strands of reinforcing material

VERSION WITH MARKINGS TO SHOW CHANGES

are formed of any suitable reinforcing fiber, such as glass, boron, carbon or the like. Moreover, the resin matrix which is used to bind the strands may be formed of any suitable thermoplastic resin or thermosetting resin. Some of the thermosetting resins which may be used include, for example, various phenolics and epoxies and many polyesters which are conventionally known for that purpose. However, the thermoplastic resins are preferred and include, for example, polypropylene, polycarbonates, etc.

Any of a number of commercially available resins can be employed for impregnating the fibers. It is only critical that the matrix should, at some stage of the process, be capable of being liquefied and softened for a period of time sufficient to flow around the fibers or filaments.

It is preferred to use individual ropes or strands of thermoplastic resin along with the individual strands of the fiber reinforcing strands. Thus, the resin strands can be commingled with the fiber strands and they can be applied as a bundle. Otherwise, the resin strands can be applied individually with the fiber strands. Upon heating, the resin will then soften and liquefy and flow around the individual fiber containing strands. When the resin is allowed to harden, an inner core will therefore be formed.

Although not illustrated, the individual first layer of aluminum [strands] wire bundle is applied in a first winding stage. Thus, the aluminum [strands] wires of the bundle can actually be

VERSION WITH MARKINGS TO SHOW CHANGES

wound about the central core after formation of same. Thereafter, the central core with the first layer of aluminum [strands] wires is passed through a second winding stage in which the second and outer layer 14 of aluminum [strands] wires of the second wire bundle are wound about the first outer layer. If additional outer layers are desired, the product is then passed through a third winding stage, etc.

It should also be understood in connection with the present invention that aluminum is only one form of current carrying conductor which could be employed as the outer skin. Thus, copper or other high current conductivity materials could be used for this purpose.

The composite core can be formed in any of a variety of ways. For example, the composite core could be extruded, as such. However, preferably, the reinforced composite when formed as a rod in the embodiment as shown, would preferably be pultruded. Several processes for this pultrusion operation are described in numerous U.S. patents as, for example, U.S. Patent No. 3,650,864 to William Brandt Goldsworthy, U.S. Patent No. 3,576,705 to William Brandt Goldsworthy, U.S. Patent No. 3,769,127 to William Brandt Goldsworthy, and U.S. Patent No. 3,579,402 to William Brandt Goldsworthy, et al.

The embodiment of Figure 1 is primarily effective for only short length cables. This is due to the fact that the reinforced plastic core 10 is not capable of significant bending movement. It

VERSION WITH MARKINGS TO SHOW CHANGES

may be appreciated that the entire cable must be capable of being wound about a drum and transported for a substantial distance where it would then be unwound from the drum and either suspended or laid at a site of use. For this purpose, the central core 10 is preferably formed of a plurality of individually shaped core sections 20, as best shown in the cable C_2 of Figure 2. In this particular case, the individual sections 20, when assembled together, create a cylindrically shaped cable 22.

In the embodiment of the invention as shown in Figure 2, six individual pie-shaped sections are provided. However, any number of sections could be provided. In connection with the present invention, it has been found that the five individual sections are preferred inasmuch as this is the number of sections which allow for a bending of the cable and a winding of the cable about a spool and which nevertheless do not create an unduly large number of sections forming the cable. In this particular case, the cable is also cylindrical in construction. This is preferred inasmuch as conventional cable using a steel core is now formed with a cylindrically shaped construction. However, any cross sectional shape could be employed.

The cable C_2 , as shown in the embodiment of Figure 2, is also wrapped with layers of electrically conductive material as, for example, individual [strands of] aluminum [wire] wires 24 and 26 which form the two outer electrically conductive layers. Again, any desired number of layers could be used. Furthermore, in the

VERSION WITH MARKINGS TO SHOW CHANGES

embodiment of Figure 2, the individual strands 24 and 26 are helically wound about the central load bearing core 22.

It has also been found in accordance with the present invention that it is desirable to have an odd number of individual sections as, for example, five, seven or nine individual sections. This allows the cable to be more easily wound about a drum. In addition, it has also been found that by causing a spiraling of the individual sections of the cable over a fairly long distance, that winding of the cable is also more easily obtained. Thus, the cable can be rotated slightly when wound about a drum so as to cause a spiraling of the individual segments. Generally, it is preferred to obtain one spiral per revolution on the drum. This has been found to reduce stresses on the cable and reduce axial build-up of tension-compressive stresses.

In connection with the following described embodiments, like reference numerals will represent like components. Figure 3 illustrates an embodiment of a cable C_3 forming part of the present invention also having a segmented central core 22 and a pair of electrically conductive outer layers 30 and 32 wrapped about the central core. In this particular case, the layers 30 and 32 are formed of individual [strands] wires which are laid longitudinally upon the central core. These [strands] wires are comprised of individual bands of electrically conductive material. However, in this particular type of construction, the bands must be secured to the conductor usually by circular retaining bands or the like.

VERSION WITH MARKINGS TO SHOW CHANGES

Figure 4 illustrates an embodiment of a cable C_4 similar to the cable C_3 , except that in this particular case, the individual pie-shaped sections 20 of the core 22 are formed with an arcuately shaped recess 34 formed at their inner most ends. In this particular embodiment, the inner most ends 34, as shown in Figures 4 and 5, form a cylindrically shaped central, axially extending bore 36 which are sized to receive a fiber optic cable 38. It can be observed that the individual sections are still tightly arranged to form a cylindrically shaped load bearing core 22, but which nevertheless formed the cylindrically shaped fiber optic cable receiving channel 36 without sacrificing the inherent strength of the overall load bearing core.

CLEAN VERSION - REPLACEMENT PAGES

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now in more detail and by reference characters to the drawings, which illustrate preferred embodiments of the present invention, C_1 illustrates an electrical transmission cable having a reinforced plastic composite load bearing core 10 and a plurality of outer layers of aluminum wire 12 and 14 extending thereabout.

By further reference to Figure 1, it can be seen that the load bearing core 10 includes a solid reinforced plastic composite member. Also, in the embodiment as illustrated in Figure 1 and the subsequently illustrated and described embodiments, there are three outer aluminum layers 12, 18 and 14 (see Figure 1), although it should be understood that any number of outer layers could be employed depending upon the desired thickness of the outer current conducting sheath to be formed over the core. It can be observed that in this construction, the cable C_1 is similar in appearance to a conventional steel core cable. Consequently, it can be laid in the same fashion or suspended in the same fashion and using the same equipment as that employed for a steel core cable.

Also by further reference to Figure 1, it can be observed that the aluminum layers 12 and 14 are formed of individual wire bundles 16 and 16¹ which are helically wound about the central core 10. Thus, the wires can be wound or otherwise applied in any conventional fashion upon the core.

In a preferred embodiment, the strands of reinforcing material

CLEAN VERSION - REPLACEMENT PAGES

are formed of any suitable reinforcing fiber, such as glass, boron, carbon or the like. Moreover, the resin matrix which is used to bind the strands may be formed of any suitable thermoplastic resin or thermosetting resin. Some of the thermosetting resins which may be used include, for example, various phenolics and epoxies and many polyesters which are conventionally known for that purpose. However, the thermoplastic resins are preferred and include, for example, polypropylene, polycarbonates, etc.

Any of a number of commercially available resins can be employed for impregnating the fibers. It is only critical that the matrix should, at some stage of the process, be capable of being liquefied and softened for a period of time sufficient to flow around the fibers or filaments.

It is preferred to use individual ropes or strands of thermoplastic resin along with the individual strands of the fiber reinforcing strands. Thus, the resin strands can be commingled with the fiber strands and they can be applied as a bundle. Otherwise, the resin strands can be applied individually with the fiber strands. Upon heating, the resin will then soften and liquefy and flow around the individual fiber containing strands. When the resin is allowed to harden, an inner core will therefore be formed.

Although not illustrated, the individual first layer of aluminum wire bundle is applied in a first winding stage. Thus, the aluminum wires of the bundle can actually be wound about the

CLEAN VERSION - REPLACEMENT PAGES

central core after formation of same. Thereafter, the central core with the first layer of aluminum wires is passed through a second winding stage in which the second and outer layer 14 of aluminum wires of the second wire bundle are wound about the first outer layer. If additional outer layers are desired, the product is then passed through a third winding stage, etc.

It should also be understood in connection with the present invention that aluminum is only one form of current carrying conductor which could be employed as the outer skin. Thus, copper or other high current conductivity materials could be used for this purpose.

The composite core can be formed in any of a variety of ways. For example, the composite core could be extruded, as such. However, preferably, the reinforced composite when formed as a rod in the embodiment as shown, would preferably be pultruded. Several processes for this pultrusion operation are described in numerous U.S. patents as, for example, U.S. Patent No. 3,650,864 to William Brandt Goldsworthy, U.S. Patent No. 3,576,705 to William Brandt Goldsworthy, U.S. Patent No. 3,769,127 to William Brandt Goldsworthy, and U.S. Patent No. 3,579,402 to William Brandt Goldsworthy, et al.

The embodiment of Figure 1 is primarily effective for only short length cables. This is due to the fact that the reinforced plastic core 10 is not capable of significant bending movement. It may be appreciated that the entire cable must be capable of being

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wound about a drum and transported for a substantial distance where it would then be unwound from the drum and either suspended or laid at a site of use. For this purpose, the central core 10 is preferably formed of a plurality of individually shaped core sections 20, as best shown in the cable C_2 of Figure 2. In this particular case, the individual sections 20, when assembled together, create a cylindrically shaped cable 22.

In the embodiment of the invention as shown in Figure 2, six individual pie-shaped sections are provided. However, any number of sections could be provided. In connection with the present invention, it has been found that the five individual sections are preferred inasmuch as this is the number of sections which allow for a bending of the cable and a winding of the cable about a spool and which nevertheless do not create an unduly large number of sections forming the cable. In this particular case, the cable is also cylindrical in construction. This is preferred inasmuch as conventional cable using a steel core is now formed with a cylindrically shaped construction. However, any cross sectional shape could be employed.

The cable C_2 , as shown in the embodiment of Figure 2, is also wrapped with layers of electrically conductive material as, for example, individual aluminum wires 24 and 26 which form the two outer electrically conductive layers. Again, any desired number of layers could be used. Furthermore, in the embodiment of Figure 2, the individual strands 24 and 26 are helically wound about the

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central load bearing core 22.

It has also been found in accordance with the present invention that it is desirable to have an odd number of individual sections as, for example, five, seven or nine individual sections. This allows the cable to be more easily wound about a drum. In addition, it has also been found that by causing a spiraling of the individual sections of the cable over a fairly long distance, that winding of the cable is also more easily obtained. Thus, the cable can be rotated slightly when wound about a drum so as to cause a spiraling of the individual segments. Generally, it is preferred to obtain one spiral per revolution on the drum. This has been found to reduce stresses on the cable and reduce axial build-up of tension-compressive stresses.

In connection with the following described embodiments, like reference numerals will represent like components. Figure 3 illustrates an embodiment of a cable C₃ forming part of the present invention also having a segmented central core 22 and a pair of electrically conductive outer layers 30 and 32 wrapped about the central core. In this particular case, the layers 30 and 32 are formed of individual wires which are laid longitudinally upon the central core. These wires are comprised of individual bands of electrically conductive material. However, in this particular type of construction, the bands must be secured to the conductor usually by circular retaining bands or the like.

Figure 4 illustrates an embodiment of a cable C₄ similar to

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the cable C₃, except that in this particular case, the individual pie-shaped sections 20 of the core 22 are formed with an arcuately shaped recess 34 formed at their inner most ends. In this particular embodiment, the inner most ends 34, as shown in Figures 4 and 5, form a cylindrically shaped central, axially extending bore 36 which are sized to receive a fiber optic cable 38. It can be observed that the individual sections are still tightly arranged to form a cylindrically shaped load bearing core 22, but which nevertheless formed the cylindrically shaped fiber optic cable receiving channel 36 without sacrificing the inherent strength of the overall load bearing core.

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